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⑦① Applicant: Exxon Research and Engineering Company
 P.O.Box 390 180 Park Avenue
 Florham Park New Jersey 07932(US)

⑦② Inventor: Maltsev, Viacheslav Boris
 Ivy Lane
 Stormville New York 12582(US)

⑦③ Inventor: Roe, Frank Leslie
 2140 Sandhill Road
 Mason Michigan 48854(US)

⑦④ Representative: Mitchell, Alan et al,
 ESSO Engineering (Europe) Ltd. Patents & Licences Apex
 Tower High Street
 New Malden Surrey KT3 4DJ(GB)

⑤④ Ink jet apparatus.

⑤⑦ An ink jet apparatus utilises a bubble trap (20) in the supply line (22) from the reservoir (44) to the inlet (18) to the jet. The bubble trap (20) includes a screen (42) at the bottom of the bubble trap on the inlet side so as to block the flow of ink through the inlet (18) with an air bubble trapped at the screen (42). A valve (60) in the ink flow line (46) leading to the bubble trap (20) is spaced from a needle (48) which pierces the septum (50) of a cartridge (44). The valve (68) is located downstream from the needle (48) and septum (50).

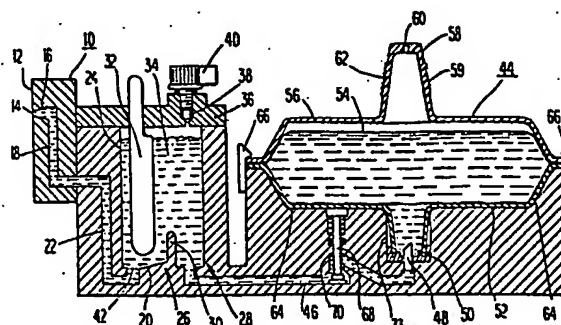


Fig. 1

"INK JET APPARATUS"

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This invention relates to ink jet apparatus, by which ink is supplied from a reservoir to one or more ink jets.

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In the operation of an ink jet or an array of ink jets, it is particularly important to eliminate the possibility of an air bubble reaching a jet or jets. If an air bubble does reach a jet, the bubble may disable the jet so as to create an irregularity in the projection of droplets if not a total disabling of the ink jet. For this reason, a bubble trap is often provided in an ink supply for an ink jet or array of ink jets. Such a trap provides a location for air to accumulate out of the ink supply path to the jet.

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Where a bubble trap is provided, the bubble trap may actually create one or more difficulties. On the one hand, it is possible that air trapped within the bubble trap may, upon inversion of the ink jet apparatus during, for example, shipping, flow into the supply line which, in turn, could block the flow of ink from the ink reservoir to the ink jet when the ink jet apparatus is reinverted. This is, of course, an extremely undesirable condition.

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A bubble trap may also provide a level of ink in the ink jet apparatus which can backflow through the system resulting in ink spillage when the supply of ink is replenished. For example, when a needle/septum connection is utilized to couple a removable ink cartridge to the ink supply system, it is possible that ink stored within the bubble trap above the level of the septum/needle connection may backflow through the system

resulting in some spillage at the needle. This can create problems for the operator of the ink jet apparatus who must replace the cartridge in the presence of spilled ink.

According to the invention, there is provided an
5 ink jet apparatus characterised in that it comprises at least one ink jet including a chamber, an orifice coupled to said chamber for ejecting droplets of ink, an inlet to said chamber and transducer means coupled to said chamber for ejecting said droplets in response to the state of energisation of said transducer means,
10 said apparatus further comprising :

an ink reservoir; and

bubble trap means coupled between said reservoir and said inlet, said bubble trap means including means having a plurality of apertures for preventing the flow of air from said
15 bubble trap means to said inlet.

In a preferred embodiment of the invention, the means having a plurality of apertures comprises a screen and the screen communicates with the bubble trap means near the bottom of the trap.

In one arrangement, the ink reservoir comprises a removable cartridge and the apparatus further comprises a receptacle for the cartridge with coupling means including needle means adapted to communicate with the septum of the cartridge to
5 couple ink from the cartridge to the bubble trap means. Valve means separate from the needle means communicates with the coupling means so as to interrupt the flow of ink through the coupling means. The valve means includes actuating means adapted to be actuated by the cartridge so as to open the valve means to permit
10 the flow of ink through the coupling means when the cartridge is present in the receptacle and adapted to be de-actuated by the cartridge so as to close the valve means to prevent the flow of ink out of the coupling means when the cartridge is absent from the receptacle.

15 In the preferred embodiment of the invention, the valve means comprises means for biasing the valve means closed in the absence of a cartridge in the receptacle. The valve means includes plunger means contacting the cartridge and the cartridge itself includes a rigid external container and a collapsible
20 flexible diaphragm within the container. The rigid container is contacted by the actuating means when the cartridge is present in the receptacle.

In operating the aforesaid apparatus, the cartridge is inserted into the receptacle. Simultaneously, the septum of the cartridge is pierced with the needle while the cartridge contacts the valve means. The valve means is then actuated so as to permit flow of ink through the coupling means downstream from the needle. When the cartridge is removed from the apparatus, contact between the cartridge and the valve means is eliminated. This closes the valve means so as to preclude the flow of ink through the coupling means downstream from the needle.

10 The invention will be better understood from the following description, given by way of example, and with reference to the accompanying drawings, in which :-

FIG. 1 is a sectional view through an ink jet apparatus representing a preferred embodiment of the invention;

15 FIG. 2 is a sectional view similar to that of FIG. 1 with the ink reservoir or cartridge substantially empty;

FIG. 3 is a sectional view similar to that shown in FIG. 1 with the substantially empty reservoir or cartridge being removed ;

FIG. 4 is a sectional view similar to that of FIG. 1
5 with the empty reservoir cartridge being replaced by a full reservoir cartridge which is being inserted into the apparatus;

FIG. 5 is an enlarged sectional view of a valve shown in FIGs. 1 through 4;

FIG. 6 is an enlarged sectional view of the
10 connection between the ink jet head and the ink supply system;

1 FIG. 7 is an inverted, enlarged sectional view
2 of the bubble trap shown in FIGs. 1 through 4;

3 FIG. 8 is a sectional view of a screen located
4 in the bubble trap; and

5 FIG. 9 is a plan view of the screen shown in
6 FIG. 7.

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8 Referring to FIG. 1, a preferred embodiment of
9 the invention comprises an ink jet system including an
10 ink jet head 10 having a face 12 which may be formed by
11 an orifice plate with one or more orifices 14. Behind
12 the orifice plate 12 is an ink jet chamber 16 which
13 is supplied by an ink inlet 18 at the rear thereof.
14 Droplets of ink are ejected from the orifice 14 in
15 response to the state of energization of a transducer
16 associated with the chamber 16 (the transducer is
17 not shown).

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19 The inlet 18 to the ink jet is supplied by
20 an ink supply system including a bubble trap 20. The
21 bubble trap 20 includes an ink supply line 22 which is
22 coupled to the inlet 18 and leads from the trap proper
23 24 which is a chamber of substantial height. Chamber
24 24 includes a first portion 26 separated from a second
25 portion 28 by a divider 30. The first portion 26 pro-
26 vides a level detection function which is accomplished
27 by a pair of spaced elongated electrodes 32, only one of
28 which is shown. The electrodes 32 may be coupled to
29 radio frequency level detection circuitry of the type
30 well-known in the art so as to indicate the height or
31 level of the ink 34 in the portion 26 as well as the

1 portion 24 of the chamber 20. The electrode 32 is shown
2 as contoured although it may be desirable to utilize
3 other configurations such as a pin to facilitate removal
4 and replacement. The top of the bubble trap chamber 20
5 is sealed off by a cap 36 having an opening 38 filled
6 by a vent cap 40. The vent cap 40 is threaded into
7 place within the opening 38 and may be rotated to any
8 of a variety of positions within the opening so as to
9 provide for appropriate venting of the bubble trap
10 chamber 20.

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12 A member having a plurality of small
13 openings in the form of screen 42 is located at the
14 very bottom of the portion 26 of the bubble trap chamber
15 at the inlet to the ink supply line 22. As will be
16 explained in further detail subsequently, this screen
17 serves the important function of preventing air from
18 entering the ink supply line 22 or the head 10 of the
19 ink jet system which would undesirably effect the
20 operation of the ink jet or jets coupled to the bubble
21 trap chamber 20.

22 The system as shown in FIG. 1 also comprises
23 an ink reservoir in the form of a cartridge 44 which is
24 coupled to the bubble trap chamber 20 by coupling means
25 including a line 46 terminated at the cartridge 44 by a
26 piercing means in the form of a needle 48. The needle
27 48 pierces or punctures a septum 50 of the cartridge
28 which allows the needle 48 to enter into the interior
29 ink supply cavity of the cartridge which is formed
30 between a lower portion 52 of the cartridge 44 and a
31 flexible diaphragm 54 located below the rigid external
32 cover 56 of the cartridge 44. The cover 56 includes an
33 upwardly extending projection 58 which provides a handle
34 59 having a top vent 60 located above gripping surfaces

1 62. The cartridge 44 is held in place in a nesting
2 receptacle 64 by latches 66.

3
4 A valve means 68 is placed in the line
5 46 so as to prevent the backward flow of ink from the
6 bubble trap 20 through the line 46 when the cartridge 44
7 is absent from the receptacle 64. As shown in FIG. 1,
8 the valve is open in response to actuation by the lower
9 rigid half 52 of the cartridge 44 when the cartridge 44
10 is present in the receptacle 64. It is important to
11 note that the opening of the needle 48 extends above
12 the path of ink past the valve 68 at the uppermost
13 height of ink in the line 46 at a point 70.

14 Referring now to FIG. 2, it will be seen
15 that the ink has been substantially drained from the
16 cartridge 44 such that the flexible diaphragm 54 is
17 collapsed down to the septum 50 of the cartridge 44.
18 When the ink reaches the level in the bubble trap
19 chamber 20 as shown in FIG. 2, a signal may be obtained
20 from the electrode 32 which indicates to the operator
21 that the cartridge should be removed as shown in FIG.
22 3. At this time, an upward force is applied to the
23 cartridge 44 to flex the latches 66 outwardly so as
24 to release the cartridge 44. It will be noted that
25 although the septum 50 is filled with ink as shown in
26 FIG. 3, the base 72 of the septum 50 is formed of an
27 elastic material so as to substantially fill the void
28 formed by the needle 48. As a result, ink within the
29 septum 50 does not flow outwardly and fill the well
30 73 which surrounds the needle 48.

31 The valve 68 including actuating plunger 74 is now free
32 to rise to the position shown in FIG. 3 forming a seal 76 within

1 the line 46. Thus, even though the ink level within the
2 bubble trap 20 is well above the open end of the needle
3 48, ink is not free to backward flow out of the needle
4 48 since the highest point 70 in the line 46 is well
5 below the open end of the needle 48 and the ink supply
6 within the bubble trap 20 is sealed off by the valve
7 68. The apparatus is now ready to be resupplied with a
8 fresh cartridge as shown in FIG. 4 whereupon the valve
9 68 will be actuated by the rigid lower cover 52 as shown
10 in FIG 4. Note that the vent cap 40 should be open when
11 a new cartridge 44 is inserted so as to allow the levels
12 within the bubble trap 20 to equalize.

13 Reference will now be made to FIG. 5 wherein
14 the enlarged view of the valve 68 is of assistance to
15 obtaining a better understanding of its operation. As
16 shown in FIG.5, plunger 74 is terminated with a cap 76
17 which is threaded onto the plunger 74. A biasing spring
18 78 is located between the cap and a washer 80 at the
19 bottom of a hole 82. In the absence of the cartridge,
20 44, the cap 76 rises to the position shown and the
21 plunger 74 moves upwardly sliding through an O-ring
22 84 which provides a seal along the surface of the
23 plunger. A flange 86 on the plunger 74 carries an
24 O-ring 88 which moves upwardly against a conical surface
25 90 in the line 46. The O-ring seal 88 pushes against
26 the surface 90 and closes the line 46 so as to preclude
27 backflow of ink through the line 46 past the valve 68.

28 Reference will now be made to FIG. 6 for a
29 more detailed discussion of the connection between the
30 ink jet head 10 and the ink supply system. As shown in
31 FIG. 6, the head 10 includes a supply tube 92 which
32 extends into the ink supply line 22 of the ink supply
33 system. An O-ring 94 circles the tube 92 so as to
34 provide a seal between the head 10 and the supply system
35 at the tube 92.

1 Reference will now be made to FIG. 7 for a
2 more complete understanding of how the bubble trap 20
3 is capable of preventing the flow of air into the ink
4 supply line 22 even when the ink supply system is fully
5 inverted as shown in FIG. 7. Referring to FIG. 7
6 wherein the components of the bubble trap are shown in
7 enlarged form, it will be seen that a bubble 96 has
8 reached the screen 42 within the trap. However, the
9 screen 42 as shown in enlarged form in FIG. 8 does not
10 permit the air to pass through the holes or apertures in
11 the screen 42. This is accomplished by sizing the holes
12 or apertures 98 as shown in the even more enlarged view
13 of FIG. 9 such that the surface tension of the fluid or
14 ink 100 at the aperture 98 cannot be broken by an air
15 bubble 102. As a result, any air within the bubble
16 trap 20 remains with the bubble trap and does not pass
17 through the screen 42.

18 As shown and described heretofore, the latches
19 66 hold cartridge 44 within the nest. If it is desired
20 to remove the cartridge 44 from the nest, force is
21 applied to the handle 59 and the latches 66 are forced
22 outwardly. In order to minimize the amount of upward
23 force to be applied for removal of the cartridge 44, it
24 may be desirable to provide a release mechanism for the
25 latches 66. This may be accomplished by a suitable
26 lever mechanism which forces the latches 66 outwardly
27 so as to facilitate the removal of the cartridge 44 in
28 response, for example, to a downward force.

29 It will also be appreciated that certain head
30 tending functions may be desirable. For this purpose,
31 it may be desirable to provide some sort of card with an
32 absorbent material which may be passed across the
33 orifice plate 12 so as to remove debris, e.g., dry ink,
34 from the orifices 14 of the head. Moreover, it may be

desirable to provide a cap for the head 10 during shipping and non-use so as to prevent the collection of debris. it will also be understood that it may be desirable to place a filter in line 46 such as a 1 to 100 micron and preferably a 10 micron teflon or
5 polyethylene filter.

The ink jet head 10 has not been described in detail. The details concerning a preferred ink jet head are set forth in U.S. patent application Serial No. 336,603, filed January 4, 1982 as well as in European patent applications 82307016.4,
10 82307017.2, 82307018.0 and 82303019.8, all filed on the 31st December, 1982.

The disclosed and illustrated embodiment features the following advantages:-

- blocking of the flow of air into an ink supply
15 system where a bubble trap is utilised regardless of the attitude of the ink jet system.

- preventing spillage of ink by backflow through the system upon replenishing of the ink supply.

- preventing spillage of ink by backflow through the
20 system when changing an ink supply cartridge.

C L A I M S :

1. An ink jet apparatus characterised in that it comprises at least one ink jet including a chamber (16), an orifice (14) coupled to said chamber (16) for ejecting droplets of ink, an inlet (18) to said chamber and transducer means coupled to
5 said chamber (16) for ejecting said droplets in response to the state of energisation of said transducer means, said apparatus further comprising :

an ink reservoir (44); and

bubble trap means (20) coupled between said
10 reservoir (44) and said inlet (18), said bubble trap means (20) including means (42) having a plurality of apertures (98) for preventing the flow of air from said bubble trap means (20) to said inlet (18).

2. An ink jet apparatus according to claim 1,
15 characterised in that said means having a plurality of apertures comprises a screen (42).

3. An ink jet apparatus according to claim 2, characterised in that said screen communicates with said bubble trap means (20) near the bottom thereof.

4. An ink jet apparatus according to any preceding claim, characterised in that said reservoir comprises a removable cartridge (44), said apparatus further comprising :

a receptacle (64) for said cartridge (44);

5 a coupling means (46) including needle means (48) adapted to communicate with said cartridge (44) to couple said ink from said cartridge (44) to said bubble trap means (20); and

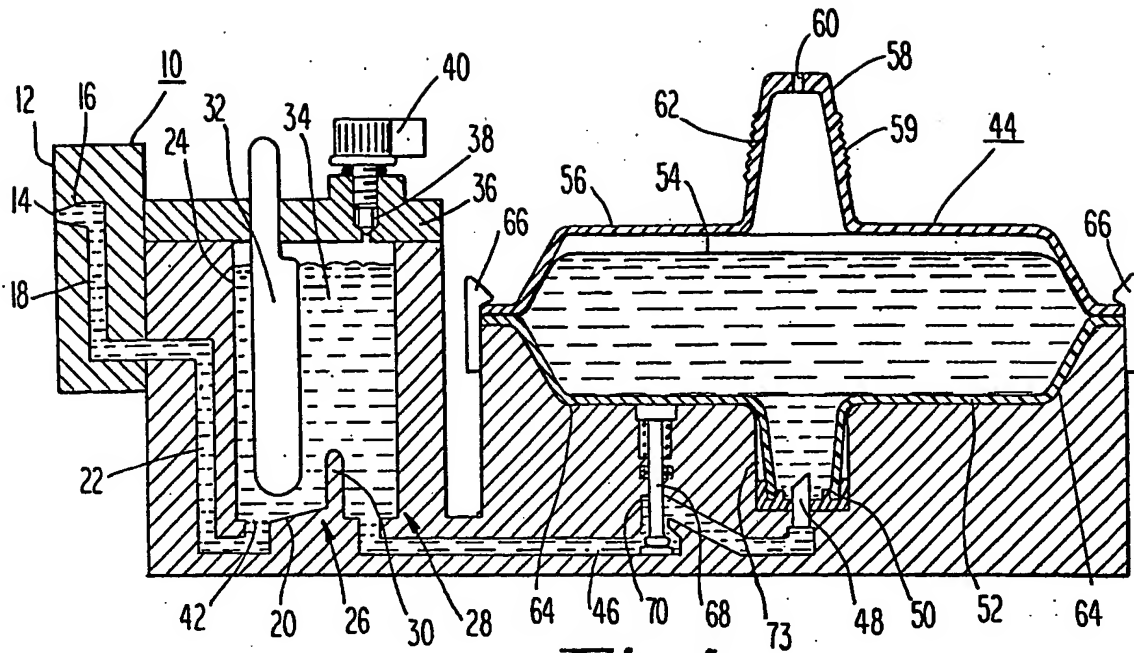
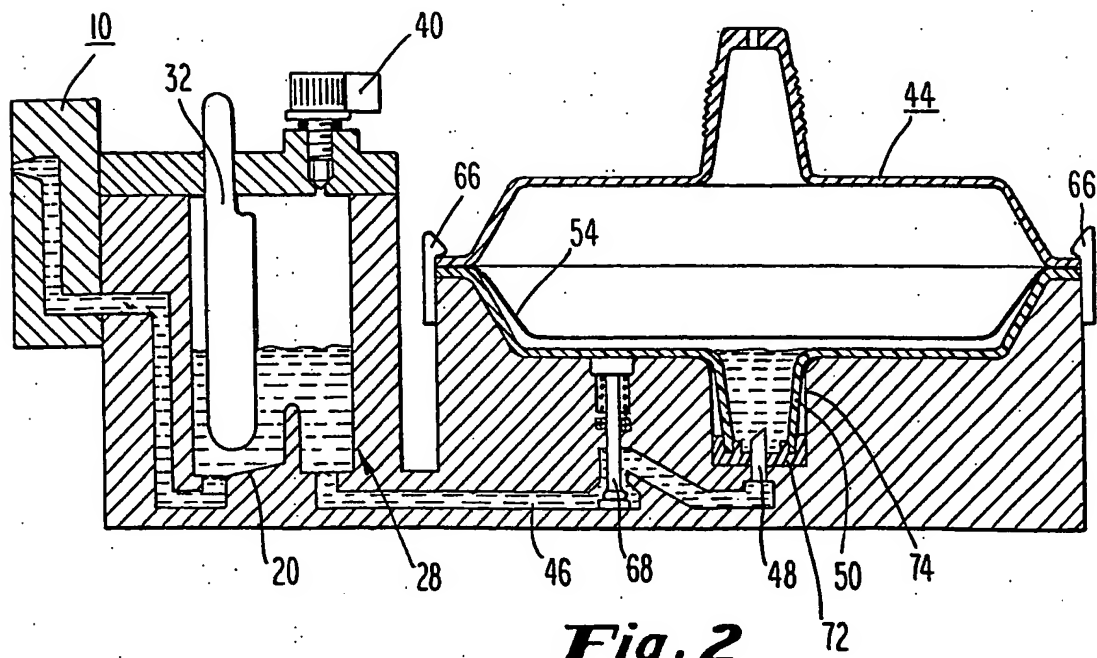
valve means (68), spaced from said needle means (48) and communicating with said coupling means (46), adapted to
10 interrupt the flow of ink through said coupling means (46), said valve means (68) including actuating means (76) adapted to be actuated by said cartridge means (44) so as to open said valve means (68) to permit the flow of ink through said coupling means (46) when said cartridge (44) is present in said receptacle (64)
15 and adapted to be de-actuated by said cartridge (44) so as to close said valve means (68) to prevent the flow of ink out of said coupling means (46) when said cartridge (44) is absent from said receptacle (64).

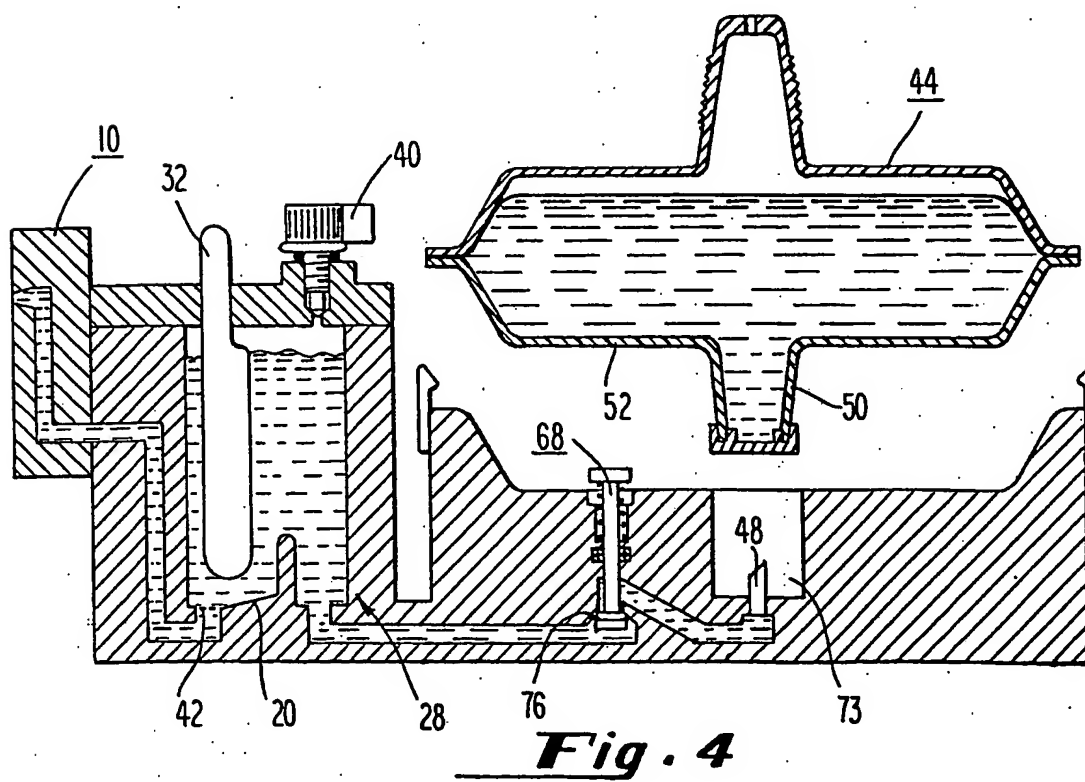
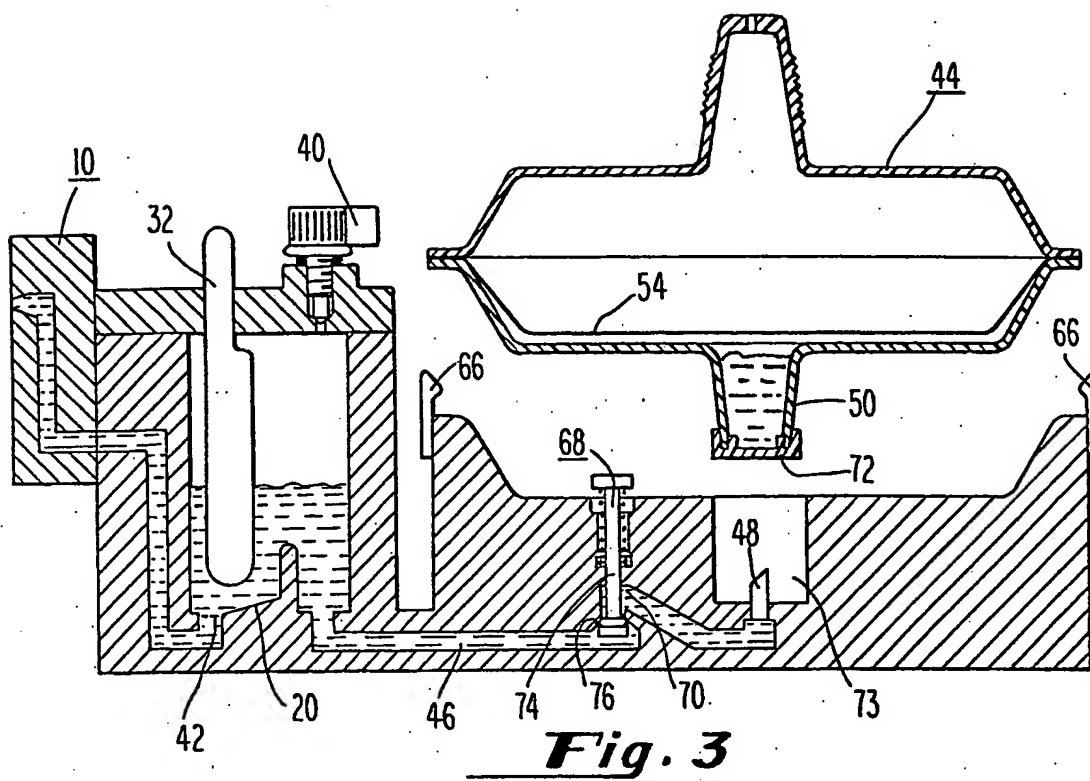
5. An ink jet apparatus according to claim 4,
20 characterised in that said valve means (68) comprises means (78) for biasing said valve means (68) closed in the absence of a cartridge (44) in said receptacle (64).

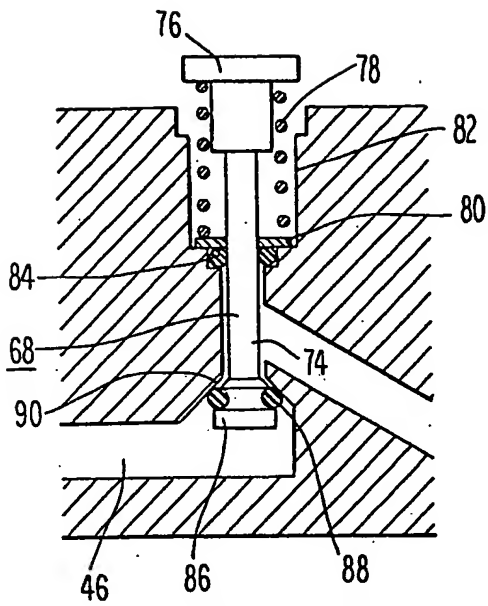
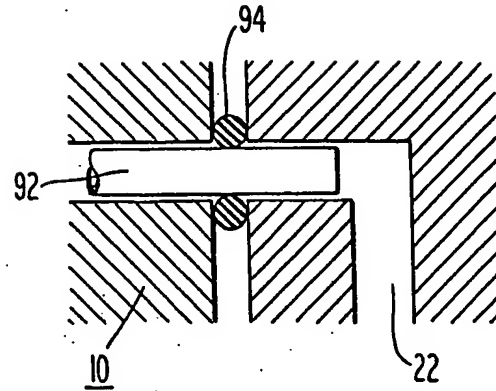
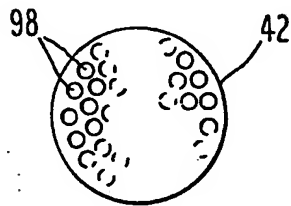
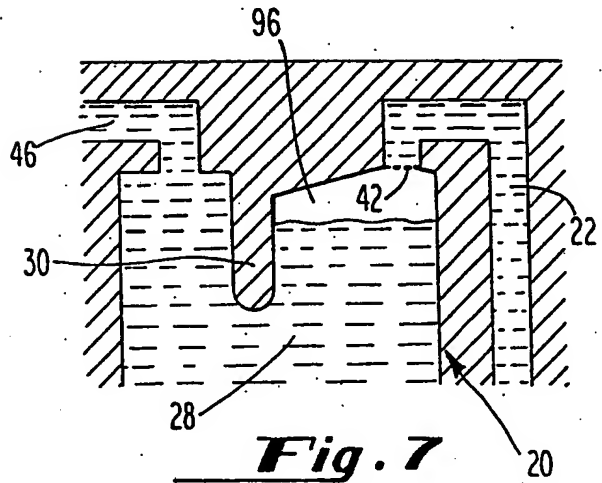
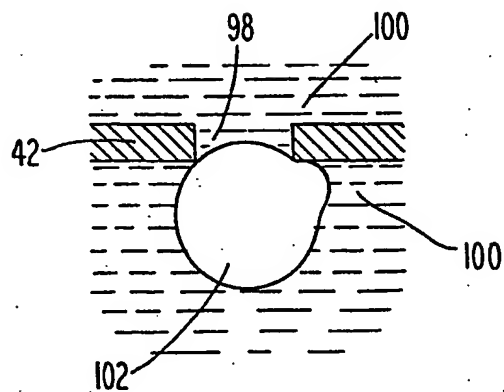
6. An ink jet apparatus according to claim 4 or 5, characterised in that said valve means (68) includes plunger means (74) contacting said cartridge (44).

7. An ink jet apparatus according to any one of claims 4 to 6, characterised in that said cartridge (44) comprises a rigid external container (56) and a collapsible flexible diaphragm (54) within said container (56), said rigid container (56) being contacted by said actuating means (76) when said cartridge (44) is present in said receptacle (64).

10 8. An ink jet apparatus according to any one of claims 1 to 3, characterised in that said reservoir comprises a removable cartridge (44) including a rigid external container (56) and a collapsible flexible diaphragm (54) within said container (56), said rigid container (56) being contacted by
15 said actuating means (76) when said cartridge (44) is present in said receptacle (64).

**Fig. 1****Fig. 2**



**Fig. 5****Fig. 6****Fig. 8****Fig. 7****Fig. 9**

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